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HAZARDOUS WASTE INCINERATOR PERFORMANCE EVALUATIONS BY THE U.S. ENVIRONMENTAL PROTECTION AGENCY

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16. ABSTRACT

This paper provides a summary of performance information gained from hazardous waste incineration testing supported by USEPA. The data and results presented focus on twelve (12) environmental performance evaluations conducted on industrial and commercial waste incinerators from 1974-1984.

Specific installations tested included liquid injection units, rotary kiln-plus-afterburner furnaces, controlled air units, and the Vulcanus ships which utilize large, unscrubbed liquid injection units. Pumpable liquids, gases, bulk solids, and containized solid-liquid materials were studied. Some units were "off-site commercial" waste disdisposal facilities, while others were "on-site, dedicated" units used for process waste streams or dedicated research installations.

These results have shown that well-designed and operated incinerators of typical sizes incinerating a wide variety of organic chemical wastes are capable of meeting current regulatory requirements with some exceptions. Most units investigated were successful in meeting the waste destruction and removal (DRE) requirement, while other requirements such as acid gas (HCl) control and particulate control were occasionally not met with some of the lower technology pollution control systems.

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ABSTRACT

The U.S. Environmental Protection Agency (USEPA), Industrial Environmental Research Laboratory-Cincinnati (IERL-Ci), wishes to present summary performance information gained from hazardous waste incineration testing supported by USEPA. The data and results presented focus on twelve (12) environmental performance evaluations conducted on industrial and commercial waste incinerators during the 1974-1984 period. Most of the units tested were land-based incinerators disposing of regulated gaseous, liquid, and solid hazardous waste, while others were ocean-going incinerator ships burning liquid wastes. This program has provided knowledge of the typical effectiveness of current incineration technology as well as guidance to USEPA's ongoing incineration R&D, sampling and analysis, and regulatory programs.

Generally, the pilot-, full-, or field-scale test results have shown that well-designed and operated incinerators of typical sizes incinerating a wide variety of organic chemical wastes are capable of meeting current regulatory requirements with some exceptions. Most units investigated were successful in meeting the critical waste destruction and removal (DRE) need, while other requirements such as acid gas (HCl) control and particulate control were occasionally not met with some of the lower technology pollution control systems.

Specific hardware installations included liquid injection units, rotary kiln-plus-afterburner furnaces, controlled air units, and the Vulcanus ships which utilize large, unscrubbed liquid injection units. Pumpable liquids, gases, bulk solids, and containized solid-liquid materials were studied. Some units were "off-site commercial" waste disposal facilities, while others were "on-site, dedicated" units used for process waste streams or dedicated research installations.

INTRODUCTION

The EPA has studied the practice of incineration of hazardous waste for some ten years now, but there has been a tendency to report this Agency's incineration results to date in numerous individual reports, rather than in a single summary document. The purpose of this report is to summarize the essential results from twelve (12) individual EPA-supported incinerator tests. In addition to the focus on these twelve tests by EPA, supplementary comments relative to a number of non-EPA supported incinerator tests are included based on information EPA has acquired through various permitting actions or site visits. In effect, this report covers some 25 to 30 or more facilities in total, or over ten percent of the roughly 230 incinerators existing in the United States at this time.

As stated in the abstract, EPA's own twelve-test incinerator performance testing data from a variety of facilities generally indicates regulatory compliance capability, especially on the issue of compound destruction and removal. The additional non-EPA supported test information noted above also shows relative compatibility with EPA's regulatory expectations. Whether or not the net 25 to 30 facility data base results to date are representative of all United States hazardous waste incinerators is not yet known. Selections of which incinerator was to be tested were not made on any formal statistical basis, rather, they were chosen randomly based on individual EPA program, industrial permit application, or waste stream research burn needs.

This report is a summary, case-by-case presentation of incinerator performance information. As a further introduction to the topic of incinerator case studies, the following section on incineration practice and related aspects is included.

Incineration Practice In The United States

Incineration has been used as a final treatment or disposal method for hazardous wastes in the United States for one or two decades at least. In 1984, it is estimated that there are some 230 industrial or government-owned incinerators which incinerate about 1.70 million metric tons of hazardous waste per year. This incinerated waste tonnage, however, is a very small portion of the current estimated 264 million metric tons per year of waste generated, of which perhaps 25.0 million metric tons per year may be classified as "incinerable".

According to EPA's information (1), about 80 percent of the existing 230 incinerators are privately owned and operated, while 20 per cent are commercial or military operations. That is, 80 percent are primarily dedicated to incinerating wastes from the private industrial companies which own and operate these incinerators on their own property. As to the generic designs of all incinerators, EPA believes that about 48 percent are liquid injection units, 19 percent are fixed hearths, 6 percent are rotary kilns, and 27 percent are various military, fluid bed, or undetermined designs at this point. Additionally, the majority of units have been installed within the past ten or fifteen years. The median capacity of individual incinerators for liquids is 150 gallons per hour, while the median capacity of solids units is about 650 pounds per hour.

The total incinerator design and marketing community consists of about 57 companies, although the majority of units installed have been sold by about 20 firms. EPA understands that 45 percent of all units have air pollution control systems, 22 percent have heat recovery capability, and generally the thermal operating conditions involve combustion temperatures of 1800°F (980°C) or higher.

Considerable amounts of hazardous wastes are also being thermally destroyed in industrial boilers or other high temperature thermal processing equipment such as cement kilns, etc., in addition to incinerators. In 1984, for example, compared to the 1.7 million tons per year noted above for incinerators, an additional 3.85 million tons per year were managed or processed through boilers and kilns, etc. The incentives for routing wastes to boilers and other industrial processes include utilization of the heating value of certain high-energy content hazardous waste streams as well as current regulatory exemptions under RCRA associated with reuse or recycling of waste. EPA has also examined the environmental performance of these non-incineration industrial thermal disposal processes during the past two or three years, but these results are not included in this report.

EPA's Regulatory Requirements For Incinerator Performance

EPA currently regulates the incineration of hazardous wastes under three different Agency program offices, depending on whether RCRA or TSCA wastes are involved, and whether land-based units or ocean-based facilities (incineration ships) are involved. Since the regulations for each of the waste categories and/or disposal method programs were developed at different time periods, under different Federal Acts, as well as at different periods of development of the understanding of incineration technology, there are some differences in regulatory language and technical requirements.

Table 1 summarizes incineration regulatory requirements for the three categories of wastes or location (i.e., land versus ocean) of the incineration facility. Chronologically speaking, the TSCA regulations are the oldest, RCRA regulations came into being next, and the ocean incineration regulations are the newest and currently exist only in a proposed draft form.

It should be noted that all three regulatory schemes include DRE or DE requirements, although the PCB requirement involves a higher DRE level due to the greater perceived hazard from PCBs versus many RCRA wastes. The EPA is working toward a determination on how dioxin wastes will be regulated where incineration is involved. Other stipulations or levels such as for temperature, residence time, oxygen levels, combustion efficiency, and the like are prevalent in the TSCA format, but are not always specified in the other regulations which tend more to be a performance rather than an operating condition kind of regulation.

Overview Observations About Incineration State-Of-The-Art

During the 1981-1984 period of EPA's recent intensive field testing of several full-scale incinerators, and including our 1974 through 1984 collection of performance information from a total of 25 to 30 field-scale incinerators, the Agency has gained a wealth of understanding about incineration state-of-the-art. The following section lists a number of overview observations which describe EPA's findings.

- In some 25 to 30 different field tests results from apparently well-designed and operated state-of-the-art incinerators where tests were conducted according to the best available EPA methods, the levels of destruction and removal efficiency (DRE) measured for principal organic hazardous constituents (POHCs) usually closely approximated or surpassed RCRA, TSCA, or ocean regulatory requirements. Exceptions usually involved either very small amounts

TABLE 1

COMPARISON OF REGULATORY REQUIREMENTS

	RCRA	TSCA	OCEAN INCINERATION (PROPOSED)
POHC DESTRUCTION AND REMOVAL EFFICIENCY (DRE)	99.99%	99.9999%	99.99% (99.9999% For PCB)
TEMPERATURE	Per Trial Burn	1200°C min. (PCB Liquids) Per Trial Burn (Non-liquid)	1100°C (Wall) min.
RESIDENCE TIME	Per Trial Burn	2 sec. min. (1200°C) 1.5 sec. min (1600°C) Non-liquid Per Trial Burn	1 sec. min.
COMBUSTION EFFICIENCY	None	99.9%	99.9%
STACK O_2	Per Trial Burn	3% min. (PCB Liquids) 2% min. (1600°C) Non-liquid Per Trial Burn	3% min.
HCl CONTROL	4 lbs./hr. max. or 99% Control	Per Regional Administrator	None
PARTICULATES	180 mg./ dscm	Per Regional Administrator	None

of POHC in the waste feed (e.g., less than 1000 ppm) or were data points generated during deliberate or accidental off-design operating conditions (e.g., lower combustion temperature, lower combustion air supply, etc.).

- Other significant performance parameters such as HCl removal, combustion efficiency (CE), temperatures, excess oxygen, and residence time, etc., were likewise normally found to be within approximate regulatory limits prescribed by applicable incineration requirements.

- DRE values obtained normally resulted from D, the destruction, rather than any significant R, removal. In general, studies of incinerators where scrubbers or similar air pollution controls were installed or even for incinerators without stack emission control devices of any kind, neither the scrubber liquids nor the particulate matter studied showed any levels of residual POHCs which could account for significant existence or need for removal (R) in the term DRE. Rare exceptions to this observation were noted in one or two cases where bottom ash samples showed some measurable residual POHC where solids were incinerated.

- Particulate generation and control was perhaps the most common deviation or problem in performance noted in terms of regulatory requirements. Normally, incinerators burning non-particulate generating wastes or incinerators with rather high-technology control equipment met particulate standards. However, several incinerators using lower technology control devices failed to meet particulate control standards prescribed by Federal or State and local rules. The successful, "high-technology" systems involved either high-pressure drop scrubbers, or electrified wet scrubbing systems.

- Many of the studies included identifying and quantifying products of incomplete combustion (PICs), defined as RCRA Appendix VIII compounds found in the stack which were not otherwise identified in the waste feed over a concentration of 100 ppm. Many such PIC compounds were found and quantified in incinerator stack effluents, however, the total mass of PICs was generally found to be less than 0.01 percent of the total POHC mass inflow to the incinerator. It is likely that other non-Appendix VIII products of combustion also occur in incinerator stack emissions, but EPA has not yet made any comprehensive studies in this

area.

- Non-stack fugitive emissions of volatile or semi-volatile compounds from incinerator systems and their support equipment can represent emissions in excess of the mass flow from the stack itself. EPA has observed varying degrees of success in controlling such emissions.

- There is a definite need for watchful observation and quality maintenance, fully instrumented control, and attentiveness by operators of hazardous waste incinerators. One should be constantly alert to any sign of off-design operation or malfunction. While most of EPA's testing indicates that a wide variety of hardware and waste combinations (i.e., mixtures of many chemical compounds fired together) can successfully comply with current regulatory performance criteria, testing usually occurred during steady or near-ideal operating periods. EPA believes that under less than favorable or off-design operation, incinerators may potentially emit increased amounts of hazardous pollutants to the environment.

- Generally, metals of various types can be present in organic waste streams. Heavy or toxic metals in detectable amounts can present a problem with incineration in that the metals are normally only oxidized or vaporized in the incinerator, not destroyed, and may also escape efficient capture in many air pollution control systems used on incinerators. Pretreatment of the wastes to remove hazardous metal content may be necessary for otherwise incinerable organic waste streams.

- Likewise, certain "organometallic" compounds (e.g., sodium cyanide, zinc-based pesticides, etc.) may be difficult to destroy and/or may result in destruction of the organic fraction but liberation of the metallic elements. More information is needed in these areas.

- EPA has observed that most successful incinerators involve combustion chamber operating temperatures in the 900 to 1000°C (1650 to 1830°F) range or higher, with some incinerators operating as high as 1500°C (2900°F).

- Residence times encountered in successful incinerators ranged from less than 0.2 seconds to as high as 6 or 8 seconds for liquid units. For solids, the residence times were several minutes to an hour.

- Improper setting or neglect of combustion air supply flows can result in poor performance.

- Plugged or malfunctioning liquid injection nozzles can cause unstable flames, flameouts, low temperatures, etc., which can impact performance.

- Charging containerized volatile wastes in amounts too large for a given size of rotary kiln and afterburner can result in puffing and intermittent periods of less than adequate performance.

- Trial burn investigation on incinerators whether small or large can be costly (e.g., $50,000 to $150,000) due to the extensive amount of chemical sampling and analytical work required with sophisticated probes and GC/MS equipment.

- Finally, additional work is needed regarding incinerating chemical compounds considered to be "acutely" hazardous such as many of the chlorinated dioxins and furans. Although these compounds have been incinerated in successfully low concentrations to date, additional testing is required with increased detection limit capability and under varied conditions (e.g., absorbed in waste soils, in high concentrations, etc.) to build confidence that these toxic compounds can be effectively destroyed by incineration.

EPA-Supported Hazardous Waste Incinerator Case Studies

Table 2 lists twelve (12) case studies which represent EPA's major efforts in obtaining pilot and field or full-scale incinerator performance data to date. In most of these cases, the EPA supported a major portion of the financial burden for conducting the performance tests on existing commercial facilities. In some cases (e.g., Cases No. 2, 11, and 12), EPA also funded the purchase or construction of the incinerator facility itself, and in others (e.g., Cases 3, some of 8, and 9), EPA's primary role was in consultation, on-site observation, and supportive analysis of the data obtained while the owner/operator of the facility supported much of the cost of the trial burn.

The following provides a brief description of the nature of each of the twelve (12) major field investigations of hazardous waste incineration supported by EPA as listed in Table 2.

Case 1, 1974 (2) - Full-scale incineration of 28 drums of 55 gallons each of commercial 20 percent DDT in oil mixtures was evaluated by EPA during its disposal in a large horizontal incinerator in Pittsfield, Massachusetts. The 20 percent DDT mixture in oil was coincinerated with the normal waste feed to the plant at the time, a 1.7 percent PCB waste. Relative feed rates were approximately 0.5 to 0.8 gallons/minute for the DDT oil, and about 0.5 to 1.3 gallons per minute for the PCB waste oil stream. EPA testing showed that the destruction and removal efficiencies for both the PCBs and DDT were in the range of 99.992 to 99.9995 percent for PCB and 99.9999 percent for all runs of the DDT. Incineration temperature ranges were 1600 to 1800°F with residence times not reported but estimated on the order of 2 to 4 seconds.

Case 2, 1974 - Pilot-scale pesticide incineration tests of nine (9) commercial Pesti-

TABLE 2

TWELVE MAJOR EPA SUPPORTED TESTS OF PILOT, FIELD, OR FULL-SCALE HAZARDOUS WASTE INCINERATORS (1974-1984)

CASE NO.	YEAR	STUDY	HAZARDOUS WASTE DESCRIPTION
1	1974	Incineration of DDT in a full-scale liquid injection unit (2)	28 drums (55 gallons each) of DDT at 20% in oil
2	1974	Pilot 3-chamber incinerator adapted from classical early garbage burners	Nine (9) commercial liquid and solid pesticide formulations
3	1974	Vulcanus incinerator ship tests in Gulf of Mexico	Mixed Shell Chemical Co. high-chlorine organic chemicals
4	1975	Full-scale industrial incinerators (3)	PVC plastic residues, organic solvents, etc.
5	1977	Vulcanus ship in South Pacific	Herbicide Orange stocks including TCDD
6	1981	Pilot-scale starved air (cont)lled-air) Los Alamos National Laboratory Incinerator (4)	PCP-treated wood
7	1981	Full-scale Cincinnati MSD incinerator (10)	Pesticide and high-chlorine liquids, HCB, HCPD, etc.
8	1981-1982	Vulcanus ship in Gulf of Mexico (2 burns) (7)	PCB liquids, TCDF, chlorobenzenes
9	1983	Vulcanus II ship in North Sea (6)	Mixed organochlorine volative compounds
10	1982-1983	Eight (8) typical field-scale commercial incinerators studied on regulatory impact analysis (RIA) program (9)	Large variety of gaseous liquid, and solid hazardous materials
11	1982-1983	EPA's Edison, New Jersey mobile rotary kiln with afterburner facility (5)	PCB, dioxins, chlorobenzenes
12	1983-1984	EPA's Combustion Research Facility pilot-scale rotary kiln with afterburner (8)	HCB and 1,2-4 trichlorobenzenes in toluene

cide formulations in three-chamber incinerator developed for EPA by Midwest Research Institute (MRI). The unit was oil fired to temperatures of 1600 to 2000°F and had nominal 100 lb/hr capacity with solids or 1 to 3 gal/hr with oil or liquids.

With the exception of metal-containing pesticides, all the organic formulations tested were destroyed to about 99.99 percent efficiency or better when exposed to 1750 to 1800°F or more. Deliberate attempts to test at lower tempertures showed that destruction continued at near 99.9+ percent levels until flame out occurred. One notable metallorganic (Zineb), produced dense white emissions of zinc oxide which escaped a three-stage wet scrubbing system. Overall, these tests supported the concept that with a nominal 1000°C (1832°F) exposure combined with approximately 2 seconds of exposure of residence time, incineration is an effective pesticide disposal technology for organic formulations.

Case 3, 1974 - EPA assisted in observing and testing the Vulcanus (I) burning Shell Chemical Company's organochlorine waste streams. Some 16,000 metric tons of liquid were destroyed to an efficiency of 99.99 percent or better at combustion temperatures of 1200 to 1500°C and residence times of about 1 second. However, EPA now considers some of the 1974 sampling and analysis techniques outdated.

Case 4, 1975 (3) - EPA conducted a series of tests on nine (9) field-scale industrial incinerator, wet oxidation, and pyrolysis facilities treating hazardous wastes. The incineration data demonstrated the feasibility of a 99.99 percent DRE standard which was first proposed for RCRA in 1978.

Industrial commentors to the 1978 proposed standard objected to the fact that some

of these 1975 field tests were conducted with "easily burned" wastes accompanied by large percentages of fuel oil, and that something closer to 99.0 percent DRE rather than 99.99 percent might be more realistic to expect from most industrial incinerators.

Case 5, 1977 - Herbicide Orange Stock Testing - EPA and the U.S. Air Force supported sampling and analysis of incineration operations aboard the Vulcanus (1) during the disposal of herbicide orange stocks with its dioxin contaminant under this combined U.S. Air Force/USEPA project involving 10,400 metric tons of material. The material was a 50-50 mixture of 2,4-D and 2,4,5-T with TCDD levels averaging about 2 ppm but ranging from 0 to 47 ppm. Destruction efficiencies met or exceeded the ocean incineration requirement for 99.9 percent in effect at the time with typical Vulcanus 1200 to 1500°C temperatures and 1 second residence times.

Case 6, 1981 (4) - Los Alamos Pilot Starved Air Incinerator - In response to concerns over disposal of stored, empty pentachlorophenoltreated wooden ammunition boxes owned by the U.S. Army in Korea and other locations, EPA supported a series of pilot incineration tests of this material. In part, the Army was concerned over the hazard which could result from the unauthorized use of this treated wood as a household fuel in Korea, given the potential for generating dioxins, etc., under poor combustion conditions. The Army wished to have representative pilot incinerator performance data from at least one example or recommended design of high temperature incinerator capable of handling this material. EPA's results showed that a destruction and removal efficiency of better than 99.99 percent of PCP was obtainable with the pilot incinerator when operated above 980°C (1800°F) with a 2.5 second residence time and further that no dioxins or furans were detectable in the stack or any other effluent stream.

Case 7, 1981-1982 (10) - Cincinnati MSD Incinerator Testing - EPA supported an extended series of full-scale incineration tests on Cincinnati's Hamilton County Municipal Sewer District (MSD) industrial waste incinerator, a large rotary kiln and cyclone plus afterburner unit. Performance on two types of waste steams was tested, e.g., on pesticide mixtures from an abandoned landfill site and a 10 to 15 percent chlorine waste mixture including HCB and other toxic compounds. In all tests of the series, destruction and removal efficiencies were near or exceeded the 99.99 percent levels, and the 99 percent HCl removal requirement was achievable.

Case 8, 1981-1982 (7) - PCB Trial Burns on Vulcanus - EPA supported and monitored the incineration of two shiploads of approximately 800,000 gallons each of 15 to 30 percent PCB waste streams in oil aboard the Vulcanus (I). Although the first trial burn was beset with sampling equipment problems, the second burn which operated at essentially identical incineration parameter conditions, i.e., 1200 to 1500°C and a nominal 1 second residence time was shown by EPA to have achieved at least 99.99 percent and probably as much as 99.9999 percent waste destruction efficiency. Minor ppm waste contaminants of furans and chlorobenzenes were also destroyed to 99.99 percent or better as well.

Case 9, 1983 (6) - The Vulcanus II incinerator ship, a new facility similar in design to the Vulcanus I vessel except for having three incinerators instead of two, was observed in 1983 by EPA during North Sea testing. The primary reason for EPA supported observation and data calculation review was to observe stack sampling train operation and data production, particularly with the newest EPA train known as the Volatile Organic Sampling Train (VOST) recently developed at that time. The liquid waste mixture studied was composed of di- and trichloroethanes, chloroform, and carbontetrachloride along with other materials. The incineration was done at normal Vulcanus incineration temperatures in the 1250 to 1500°C range with about 1 second residence time. Destruction efficiencies for all compounds ranged from 99.998 to 99.999995 percent for these compounds.

Case 10, 1982-1983 (9) - Regulatory Impact Analysis (RIA) Testing Series - EPA conducted a series of several days of tests of eight (8) typical industrial/commercial full-scale RCRA hazardous waste incinerators of various sizes and designs burning a wide assortment of gaseous, liquid, and solid forms of multicomponent chlorinated and non-chlorinated waste streams. The program was designed to evaluate typical existing incinerator performance. Each facility was studied while burning normal inventories, under closely monitored conditions and sampled and analyzed with modern stack and effluent evaluation methodology. Most if not all units tested were found to closely meet or exceed the 99.99 percent DRE and 99 percent HCl removal RCRA regulatory requirements, although some units could not meet the particulate emission standards. Combustion conditions were in the range of 820 to 1100°C (1500 to 2075°F) in temperature and 0.2 to 6.5 seconds of residence time.

Case 11, 1982-1983 (5) - Tests With EPA's Mobile Incinerator at Edison, New Jersey - EPA conducted a series of trial burn-type performance evaluations on liquid PCB and chlorobenzene formulations during an initial check-out of this new incinerator. The wastes, although in liquid form, were injected into the rotary kiln operated in the 890 to 960°C range, followed by the afterburner operated in the 1 in the 1180 to 1250°C range of temperature. Residence times were of the order of 2 seconds in each chamber for a total of roughly 4 seconds for all hot zones of the unit. The tests showed successful performance, e.g., DREs were calculated in the range of 99.9999 percent or greater for PCBs, and also 99.9999 percent for compounds such as tetrachloromethane, di-, tri-, and tetrachlorobenzenes present in minor amounts in the mainly PCB wastes fired.

The facility is nominally a pilot-scale unit, though larger than many pilot units, having a nominal liquid capacity of about 1 gal/min and an eventual solids capacity upon adding feed systems of 1/2 to 1 ton/hr or so. HCl captured during PCB tests exceeded regulatory needs at 99.95 to 99.99 percent, while particulates were also well controlled at about about 22 to 60 mg/m^3 with this liquid waste.

Case 12, 1983-1984 (8) - Tests at EPA's Combustion Research Facility, Jefferson, Arkansas Initial testing at this facility on its pilot-scale rotary kiln with afterburner has demonstrated the unit's effectiveness on two commerical pure chemicals fired in liquid form, hexachlorobenzene (HCB) and trichlorobenzene (1,2-4 TCB) dissolved in toluene. DREs of the order of 99.996 to 99.9996 percent were regularly obtained for different sampling runs with these compounds. Temperatures ranged from 1600 to 2000°F (870 to 1090°C) and residence times in the 1 to 3 second range. The purpose of the testing was to obtain baseline data for the incinerator prior to proceeding with additional chemicals under an extensive testing matrix involving standard and off-design operating conditions.

Typical Operating Characteristics Of Incinerators Which Have Met Regulatory Requirements

EPA has been reviewing all available successful incinerator performance data with an interest in identifying any common or desirable patterns or ranges in typical operating characteristics. Our interest has been in trying to identify key operating parameters which may some day serve as reliable surrogates of destruction and removal (DRE) performance. At some future time, it is hoped that these surrogates such as temperature, CO, CO_2, THC, and other behavior patterns may actually replace the current need for detailed and costly trial burns, or at least to boost confidence in their current use as sufficient real-time monitoring parameters for extended periods after an initial trial burn period.

As shown in Table 3, all of EPA's data thus far on successful incinerators does appear to fall within certain ranges of values of various parameters. However, in many cases, these ranges can be rather wide (e.g., temperature from 820°C to 1500°C, etc.) and in some cases, there are some outlying points as in the case of CO and THC. The latter, CO and THC, were furtherest along in EPA's view in becoming the best choice of surrogates in lieu of trial burns until the outlying points were discovered just recently. Intensive studies on these issues are continuing on a laboratory and pilot basis at EPA.

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TABLE 3

TYPICAL OPERATING CHARACTERISTICS OF INCINERATION MEETING REGULATORY REQUIREMENTS ON DESTRUCTION AND REMOVAL EFFICIENCY

Combustion Chamber Temperature Level:	820°C to 1500°C (1500°F to 2700°F)
Residence Time:	0.2 sec to 6.5 sec for gases and liquid/vapors
	several minutes to 1/2 hour for solids/sludges
Excess Combustion Air:	60 to 130 percent
Stack Gas Composition:	
Oxygen :	8 to 15 percent
Carbon Dioxide :	6 to 10 percent
Carbon Monoxide :	0 to 50 ppm (with rare exceptions up to 500 ppm or more)
Total Hydrocarbons:	0 to 5 ppm (with rare exceptions up to 75 ppm or more)
Stack Particulate Emissions:	
Units Without Control Devices:	60 to 900 mg/dscm (0.03 to 0.39 gr/dscf)
Units With Control Devices :	20 to 400 mg/dscm (0.01 to 0.17 gr/dscf)

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